International Journal of Research Publication and Reviews

Journal homepage: www.ijrpr.com ISSN 2582-7421

Microcontroller Based Solar Tracking System

Dhiraj Patil[1], Mahesh Tarne[2], Manoj Mahadik[3], Kiran Valvi[4], Jayarajesh Vattam[5], Amresh Kumar[6]

1 2 3 4 5 Department of Electrical Engineering, Mumbai University ARMIET,Shahapur,Thane,Mumbai University

ABSTRACT-

The main objective of this project is to create and evaluate a solar tracking which have to maximize the power output of the solar plate. The design of the solar tracking structure include of some electronic components such as an Microcontroller, Two light-dependent resistors (LDRs), DC motors, and solar plate.esigning a solar tracking system can indeed help maximize the power output of a solar panel by continuously adjusting its orienDtation to capture the maximum amount of sunlight throughout the day. The components you mentioned are commonly used in such systems.

Keywords: Solar tracker, LDRs, DC motor, Microcontroller, Solar plate.

INTRODUCTION

Photovoltaic (PV) solar technology is indeed a graceful and efficient way of harnessing solar energy. It involves the use of semiconductor materials, typically made of silicon, which have theproperty of the photoelectric effect. The photoelectric effect allows certain materials to absorb photons (particles of light) from sunlight and release electrons, generating an electric current.

Photovoltaic cells, also known as solar cells, arethe building blocks of PV systems. These cells are made up of layers of semiconductor materials, usually silicon, with different electrical properties. When sunlight hits the solar cell, photons with enough energy can knock electrons loose from their atoms in the semiconductor material. The freed electrons create a flow of electric current when captured and directed through an externalcircuit.

The electric current generated by individual solar cells is typically small, so multiple cells are interconnected to form a solar module or panel. These modules can be connected in series or parallel to increase voltage or current, respectively,and form a photovoltaic array.

Solar photovoltaic systems have numerous advantages. They produce electricity without emitting greenhouse gases or other pollutants, making them a clean and environmentally friendly energy source. Solar energy is also renewable, as theSun's energy is abundant and will continue to be available for billions of years. Additionally, solarPV systems require minimal maintenance, with no moving parts in the solar cells themselves, leading toreduced operational costs.

Definition

A Solar tracker is an automatic solar plate which actually follessed the sun to get more power. The primary advantage of a tracking system is to collect solar energy for the largest period of the day, and with the most accurate set up the Sun position shifts with theseason.

Objective of the project

It seems like your project's objective is to design and construct a solar tracking system that maximizes the alignment of the solar plate perpendicular to the Sun'srays. This approach aims to optimize the power outputof the solar panel by ensuring that it receives sunlight at a 90-degree angle.

METHODOLOGY

Hardware implementation

It's important to ensure that the selected components are compatible with each other and meet the requirements of your project. Additionally, consider the power supply, circuit connections, and any additional components or peripherals required for interfacing and control.The main components usedare 8051 Microcontroller, light-dependent resistor (LDR), DC motor, and solar plate.

8051 microcontroller

The 8051 microcontroller is a popular choice for many projects due to its simplicity, versatility, and availability. It is an 8-bit microcontroller with a wide range of features and capabilities. When selecting an 8051 microcontroller, consider factors such as clock frequency, memory (program memory and data memory), number of I/O pins, and communicationinterfaces (such as UART, SPI, I2C) based on your specific requirements.

Light-Dependent Resistor (LDR)

LDRs are analog light sensors that exhibit varying resistance based on the intensity of light falling on them. When choosing an LDR, consider its resistance range, response time, and spectral sensitivity. LDRs with high sensitivity to visible light are commonly used in solar tracking systems. Ensure that the LDRs can accurately detect changes in light intensity to provide reliable input for tracking the Sun's position..

Solar plate

The solar plate, or solar panel, is responsible for capturing sunlight and converting it into electricity. The specifications of the solar panel depend on variousfactors, including desired power output, efficiency, andsize constraints. Consider parameters such as maximum power output (in watts), open-circuit voltage, short-circuit current, and operating voltage when selecting a solar panel. Additionally, factors like the type of solar cells (monocrystalline, polycrystalline,or thin-film) and the panel's dimensions may impact your design choices.

DC motor

DC motors are used to physically move the solar plate and align it with the Sun's position. Consider the torque, speed, and power requirements when selectinga DC motor. The torque should be sufficient to rotate the solar plate with ease, and the speed should be controllable to achieve precise tracking. Additionally, choose a motor with low power consumption to ensure energy efficiency..

Figure 2.1: DC Motor

2.1.5 Motor Driver

When selecting a motor driver module, consider factors such as maximum current rating, voltage compatibility, control interface (e.g., PWM or analog), and additional features like built-in protections. The choice of motor driver depends on the specific requirements of the motor being used and the control circuitry it interfaces with.It's essential to refer to the motor driver's datasheet and documentation for proper wiring, pin configurations, and operational guidelines to ensure safe and reliable motor control .

Research Design

It's great to see your enthusiasm for utilizing solar energy and developing the automatic solar tracking system project. The components you mentioned, including the solar plate, DC motor, 8051 Microcontroller, motor driver, LDR sensor module, and resistor circuit, are essential for theimplementation of such a system.

By incorporating the LDR sensor module along the edges of the solar plate, the system can detect the intensity of sunlight falling on different parts of the plate. This information can be used by the microcontroller to determine the position of the Sun and control the DC motor through the motor driver.

The motor driver enables the microcontroller to provide the necessary current and voltage to the DC motor for adjusting the position of the solar plate. As the Sun moves throughout the day, the microcontroller receives input from the LDR sensor module and calculates the optimal position for thesolar plate to face the Sun directly, maximizing the absorption of solar energy.

Implementing an automatic solar tracking system allows for the efficient utilization of sunlight and the maximization of solar energy production. By continuously aligning the solar plate with the Sun's position, the system aims to increase the power outputof the solar panel compared to a fixed orientation system.

Moreover, promoting the use of solar energy as aclean and renewable source can contribute to addressing environmental concerns, particularly related to pollution and climate change. By harnessingsolar power, this project has the potential to provide a sustainable and valuable energy source for various applications.

As you move forward with the project, ensure to plan the circuit design, connections, and programming of the microcontroller appropriately. Conduct thorough testing and calibration to optimize the performance of the solar tracking system.

Hardware Design

It seems like you have provided a detailed description of the construction and components used in the automatic solar tracking system project. Here's a summary of the key points you mentioned: Components used:

Solar plate: Provides a 12-volt output.

8051 Microcontroller: Serves as the main control unit for the solar tracking system.

Motor driver (IC L293D): Controls the DC motor's operation and movement.

LDR sensor modules: Used to detect sunlight and provide input to the microcontroller.

10 RPM DC motor: Rotates the solar plate based on the control signals from the microcontroller.

Current sensor: Measures the current flow within the system.

9V battery: Provides power to the system. Construction: The project is built on a wooden base placed on the ground. Iron rods are fixed in a cross- shape manner on both sides, connected by a cylindrical rod without any holes. The DC motor is mounted on one edge of the cylindrical rod. The circuit of the solar tracking system is divided into three sections.

Input stage: Two LDR modules are arranged to form a voltage divider circuit, which detects sunlight and provides an input signal to the microcontroller.

Microcontroller: The 8051 microcontroller is programmed to process the input from the LDR modules and determine the optimal position for the solar plate. It sends control signals to the motor driver based on this calculation.

Driving circuit: The motor driver, specifically the IC L293D, is connected with three terminals. Two terminals are used for motor input/output, while the third terminal is for power input. The motor input terminals are connected to two digital input/output pins of the microcontroller, and the motor output terminal is connected to the DC motor.

By utilizing this construction setup and the control circuit, the solar tracking system is designed to detect sunlight through the LDRs and actuate the DC motor to position the solar plate for maximum sunlight reception.

It's important to ensure proper circuit connections, program the microcontroller correctly, and perform thorough testing to verify the system's functionality and accuracy in tracking the Sun's position.

Please note that further implementation details, such as the specific circuit diagram, code, and additional considerations, may be required for a complete understanding and successful execution of the project.

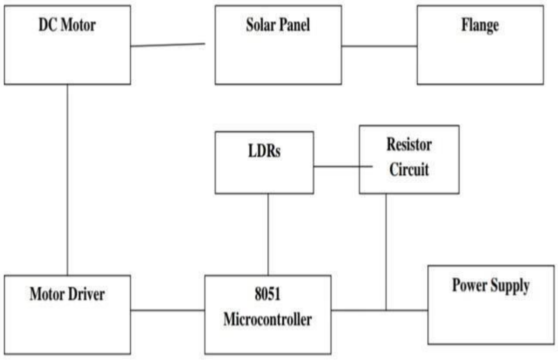

Figure 2.2: Block diagram for the solar trackingsystem

Maximum power point tracking

the electrical behavior of a photovoltaic cell is characterized by parameters such as the fill factor (FF), open-circuit voltage (VOC), and short-circuit current (ISC). These parameters help determine the performance and efficiency of a solar cell under different environmental conditions.

Fill Factor (FF): The fill factor represents the ratio of the maximum power output of a solar cell to the product of VOC and ISC. It is a measure of how effectively the solar cell converts sunlight into electrical power. The fill factor indicates the extent of non-linear electrical tendencies within the cell, including losses due to recombination, resistance, and other factors. A higher fill factor corresponds to better performance and efficiency.

Open-Circuit Voltage (VOC): The open-circuit voltage is the maximum voltage across the terminals of a solar cell when no load is connected. It represents the maximum voltage that the solar cell can generate when not delivering any current. VOC depends on various factors, including the bandgap energy of the semiconductor material used in the solar cell and the temperature. It provides important information about the cell's ability to generate electricity under different lighting conditions.

Short-Circuit Current (ISC): The short-circuit current is the maximum current that a solar cell can deliver when the terminals are shorted together. It represents the maximum current output of the solar cell under optimal illumination. ISC is influenced by factors such as the intensity of sunlight, cell design, and material properties. It is an essential parameter for understanding the cell's current-generating capacity. By considering these three parameters—fill factor, open-circuit voltage, and short-circuit current—it is possible to assess the electrical characteristics and tendencies of a photovoltaic cell. These parameters help evaluate the performance and efficiency of the solar cell and provide insights into how it will behave in different environmental conditions.

When designing or selecting photovoltaic cells for specific applications, it is important to consider these parameters alongside other factors such as the cell's efficiency, temperature coefficient, spectral response, and long-term reliability to ensure optimal performance and desired outcomes.

Favorable conditions for maximum power point tracking :

MPPT (Maximum Power Point Tracking) is a technique used in photovoltaic systems to maximize the power output from solar panels under varying environmental conditions. While it is true that MPPT isparticularly beneficial in certain conditions, it isimportant to clarify some misconceptions in your statements.

MPPT in Cold and Cloudy Weather: Contrary to what was mentioned, PV modules typically have lower efficiency during cold and cloudy weather conditions compared to sunny conditions. This is because solar panels rely on sunlight to generate electricity, and reduced sunlight availability negatively affects their performance. However, MPPT can still be beneficial during such conditions by dynamically adjusting the operating point of the PV system to capture the maximum available power. By continuously tracking and adjusting the operating point to the MPP, MPPT enables the system to extract the maximum available power from the solar panels and deliver it to the batteryor load.

Where is the MPPT tracker should be placed?

The MPPT (Maximum Power Point Tracking) tracker should be placed in the power conditioning stage of a photovoltaic (PV) system, between the solar panels andthe battery or load. It is typically integrated into the charge controller or inverter of the PV system.Solar Panels: The PV modules, also known as solar panels, capture sunlight and convert it into electrical energy. They are typically mounted on rooftops, open fields, orother suitable locations with maximum exposure to sunlight.MPPT Tracker: The MPPT tracker, as mentioned earlier, is responsible for continuously tracking the maximum power point (MPP) of the solar panels. It adjusts the operating point of the PV system to extract the maximum available power. The MPPT tracker is usually integrated into the charge controlleror inverter.Charge Controller: In systems with batteries, a charge controller is used to regulate and control the charging process. It manages the flow of current from the solar panels to the batteries, preventing overcharging and optimizing battery performance.

Advantages and Pitfalls of Solar Energy:Advantages: -

Renewable and Sustainable:

Solar energy is derived from sunlight, which is a renewable resource. As long as the Sun exists, we can harness its energy for power generation. Solar energy is abundant and sustainable, unlike fossil fuels that are limited and contribute to environmental degradation.

Environmentally Friendly:

Solar energy is a clean source of energy that produces no greenhouse gas emissions or air pollutants during operation. It helps reduce carbon footprint, mitigate climate change, and improve air quality.

Energy Independence: Solar energy offers the potential for energy independence, reducing dependence on fossil fuel imports and the associated geopolitical issues. It provides an opportunity to generate electricity locally, on rooftops, or in remote areas, thereby enhancing energy security and resilience.

Reduced Energy Costs:

While the upfront costs of installing solar panels may be significant, solar energy can significantly reduce electricity bills in the long run. Once installed, solar systems have low operational and maintenance costs, leading to savings on energy expenses over their lifespan. .

Job Creation and Economic Benefits:
The solar industry has become a significant source of job creation and economic growth. As solar energy adoption increases, there are opportunities for employment in manufacturing, installation, maintenance, and research and development..

Pitfalls: -

Intermittency and Weather Dependency:
Solar energy availability is dependent on sunlight, making it intermittent and subject to weather conditions. Energy production fluctuates throughout the day and is reduced during cloudy or rainy periods.

Land and Space Requirements:
Solar power plants or large-scale installations require significant land or space for the installation of solar panels. This can be a limitation in densely populated areas or where land availability is limited.

Upfront Costs and Financing:
The initial investment for installing solar energy systems can be high, including the cost of solar panels, inverters, and installation. Financing options such as loans or leasing agreements can help overcome this barrier.

Manufacturing and Recycling:
The production of solar panels involves the use of various materials and manufacturing processes that may have environmental impacts. Additionally, the proper recycling of solar panels at the end of their lifespan is an emerging concern to minimize waste and ensure responsible disposal.

Geographic Limitations:
Solar energy may be more suitable for regions with abundant sunlight, such as sunny or tropical areas. In areas with limited sunlight or high latitude regions, solar energy may be less efficient or require larger installations to compensate for lower solar irradiance.

RESULT

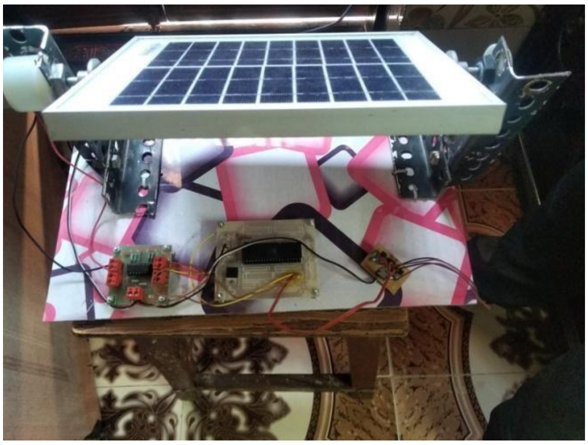

Figure 3.1: Complete Setup Of 8051 Microcontroller Based Solar Tracker System

CONCLUSION, FUTURE ,SCOPE

The results of the outdoor experiment demonstrate theeffectiveness of the solar tracking system inmaximizing the efficiency of the solar plate. The implementation of the solar tracker mechanism led toa significant increase in efficiency, with a measuredefficiency of 38.89% compared to a static solar plate. The advantage of using a solar tracking mechanism isevident throughout the day as it continuously tracksthe Sun's position, allowing the solar plate to absorbmore solar irradiance and generate more electricity.This ultimately results in a reduction in the cost ofelectricity production. Dual-axis tracking, in particular, has shown to generate 40% maximum power compared to fixed solar plates. This means that with the same number of plates, frames, and other components, the power output can be achieved at a lower cost, offsetting the additional expenses for the tracking hardware. Alternatively, using the same number of plates as originally planned can result in a 35% increase inpower generation and higher returns on investment. The specific financial aspects of the project will determine the payback time and overall returns.

Future Scope

The "Automatic Solar Tracking System" project serves as a trailblazer in addressing futuristic problems and promoting sustainable development. By maximizing the efficiency of solar energy utilization, this system offers numerous advantages, both in termsof economic viability and accessibility.
One of the key benefits of the automatic solar trackingsystem is its enhanced efficiency. By continuouslyadjusting the position of the solar plate to align with the Sun's rays, the system optimizes the absorption of solar irradiance. This results in increased electricity generation and improved cost-effectiveness comparedto fixed solar panel systems. Moreover, the higher efficiency of the system contributes to a reduction in pollution and environmental impact.
In a world where pollution poses significant challenges to various aspects of advancement and productivity, the automatic solar tracking system stands as a beacon of progress. By harnessing clean and renewable solar energy, it helps combat pollution and reduces dependence on fossil fuels. This not only improves air quality but also mitigates the harmful effects of greenhouse gas emissions, thus contributingto a healthier and more sustainable environment.
Furthermore, the automatic solar tracking system offers accessibility to a wide range of users. Its design and implementation can be tailored to suit differentapplications, from residential rooftops to large-scalesolar power plants. This adaptability ensures that the benefits of solar energy are not limited to a select few but can be harnessed by individuals, communities, and industries across various sectors.
In summary, the "Automatic Solar Tracking System" project represents a significant advancement in addressing the challenges posed by pollution and limited resources. By promoting efficient utilization of solar energy, it paves the way for sustainable development, economic viability, and a cleaner environment.

REFRENCES

1. Ying-Tung Hsiao, China-Hong Chen, “Maximum Power Tracking for Photovoltaic Power System,” Conference Record of the 2002 IEEE Industry Applications Conference. 37th IAS Annual Meeting, ISBN-0-7803-7420-7, 13-18 Oct, 2002, pp 1035- 1039.
2. Mayank Kumar Lokhande, “Automatic Solar Tracking System,” International Journel of Core Engineering & Management, October, 2014.
3. Scott J Hamilton, “Sun-Tracking Solar Cell Array System,” University of Queensland, Department of Electrical Engineering, 1999
4. Furkan Dincer, Mehmet Emin Meral, “Critical Factors that Affecting Efficiency of Solar Cell,” University of Yuzuncu Yil, Department of Electrical and Electronics Engineering, Van, Turkey, 2010.